European Cave Rescue Association

Technical Commission
Underground Communications

Contents

Introduction

At the ECRA conference in Rudice (Czech Republic) in 2022 and in discussion with Giuseppe Conte and Dinko Novosel, it was thought that a comprehensive list of communication devices available to cave rescue teams should be provided. In the end it was decided that Pete Allwright (ECRA Honorary Member) would be tasked with producing the first issue of such a document.

This fourth edition offers major update and the addition of the “Mesh Radios” category.

Format of document

The document is in two sections.

The first section is a number of tables identifying the available communications devices.

The second section provides a detailed description of several devices, expanding on the content of the tables in the first section. This includes the new Mesh Radios section.

Prices

The prices quoted are from the time when the radio was added to the catalogue and may not have been updated.

It remains that in the current climate, any prices should be treated as volatile. Inflation, currency rates and tariffs may affect the end price.

CREG

Mention is made in several places of the *CREG Journal*. CREG is the Cave Radio and Electronics Group of the BCRA – the British Cave Research Association. The *CREG Journal* covers the application of technology to the exploration and study of caves, with cave communication being a major theme.

The CREG Journal is published four times per year and is available either as a printed magazine or as a download. A small subscription fee applies. If you want more information please take a look at https://bcra.org.uk/pub/cregj/ or contact creg-editor@bcra.org.uk.

Queries

Any questions regarding the contents should be directed to the ECRA Communications Officer unless indicated otherwise. Contact at communications@caverescue.eu who will forward the request.

Thank You

Again a big thank you to all who have responded and contributed. This is a collaboration between the authors of the various contributors too many to mention here.

This is a live document so if you have any additional contributions or changes, please contact communications@caverescue.eu with the details.

Version History

Version	Date	Description	Author
0.1		Draft	Pete Allwright
0.2	Jan 2023	Changes	PA
0.3	Mar2023	Updates from member organisations	PA
0.4	Mar 2023	Updates from Germany	PA
1.0	3rd April 2023	First publication	PA
1.10	1st March 2024	First update Spellcom radios added; CaveLink, Nicola 4 and µHeyPhone updated.	PA
1.50	8th April 2025	Rationalise version numbers. Added Lovell Earth Return Telephone; QDX-M Cave Radio.	PA

		Added CTS Phones and ERMES. Added details of Australian communications. Added Bulgarian wired telephones. Updated Pimprenelle; Nicola 4; Cavelink Latest µHeyPhone details published.	
1.60	April 2026	Added the Mesh radio category. Added Overview for Wireless radios. Added Ogofon. Added SPL+, SPL+ PC and Dataphone. Added Meshtastic radios. Added Ether (Radio-Telephone Link). SpellCom updated. QDX-M minor updates. Updated Pimprenelle. Updated Nicola 4.	PA

Known Obsolete Devices

Name	Country of Origin	Date	Outline	Description	Costs	Status
Molephone	Britain	1980s	Developed in the late 1970s and 80s by Bob Machin at Lancaster University. Served CRO well for over 20 years	Used loop aerials. Max depth 300 metres. Could radio locate. External batteries.	-	Obsolete
Ogofon	Britain	1987	Developed by Bob Williams Ian Todd and written up in Caves & Caving 35 (Spring, 1987). Originally, it operated on 125kHz but later units were tuned to 87.5kHz. The recommended antenna was a 1m square loop antenna.	Used loop aerials. Max depth 200 metres.		Obsolete
HEYPhone	Britain	1990s	Developed by John Hey for the BCRC.	Used linear aerials; best performance was 1 kilometer in Peak Cavern. Capable of home build – 1980s technology. External batteries.	-	Obsolete – parts not available.
Nicola 2	France	1990/2000	Development lead by Graham Naylor with the SSF in the Vercors.	Used linear aerials. Capable of 1 kilometer – also tested in Peak Cavern. External batteries.	-	Obsolete. Still used by some organisations. Might be difficult to repair.

Name	Country of Origin	Date	Outline	Description	Costs	Status
TEDRA	SPAIN	2007	SIEMENS / Hostile Environments Technologies Group of the Zaragoza University	Used linear aerials. Capable of 1 Km External batteries	Was €2.000	Out of production (April 2024)
Transistor Intercom 2-way	Germany	2003		Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.	Was intercom system bought on ebay (40€) and modified.	Obsolete – out of production
?? Phone?	Australia	1960s →	Two wire telephone	Very similar to Michie Phone but used with two wires… Open source.	Speakers are no longer available.	Used in Victoria.

Wired Communications Devices

Name	Country of Origin	Date	Outline	Description	Costs	Status
CAVE-SYS	Poland	2014	CAVE-SYS system designed to provide voice communication in confined spaces.	Leaky Feeder Cable technology. Special coaxial cable (thin and flexible, diameter 9mm, weight 5kg/500m) works as distributed antenna and provides radio coverage on VHF band (e.g. 139MHz) to handheld radios in range of LFC radiation (depend of underground structure, a few dozen meters.	€6000 – 2017 price	can be ordered from manufacturer
Cavelink2	Switzerland	2003	Ingenieurbüro Ziegler GmbH Developed by Felix Ziegler.	Embedded together with wireless operation. See below for wireless devices. Operates over single wire or twisted pair.		
Cavelink4	Switzerland	2024	Ingenieurbüro Ziegler GmbH Developed by Felix and Simon Ziegler.	Embedded together with wireless operation. See below for wireless devices. Operates over single wire or twisted pair.		
Ex-Heulruf-Telefon (howl-call telephone)	Germany		Manufacturer Funke+Huster Fernsig	Developed for mining No power supply (sound-powered telephone system with dynamic transmitter and receiver capsules)	Prices range from 30-125€	Maybe available on eBay
Lovell Earth Return Telephone	Britian	1993 modified 2012	Earth return single wire telephone	For self-construction described in the CREG Magazines 13 (Sept 1993), 14 (Dec 1993), and 78 (June 2012). Still used but classified as obsolete because the earphone is difficult to obtain.	Around €100	The earphone/ microphone capsule is the hearing capsule used in old analogue telephones, or in sound powered

Name	Country of Origin	Date	Outline	Description	Costs	Status
						field telephones (Heulruf telephone)
Michie Phone	Australia	1960s →	Earth return (single wire) telephone	Developed by Neville Michie. Aluminium handsets and no amplification. Open source. Speakers are no longer available. Volunteer built. Hundreds of handsets around the country.		Used by cave rescue in all states except Victoria. Have served very well for 50+ years, but lack of amplification is a problem in noisy environments.
Michie Phone base station	Australia	2015 →	Amplified speaker/mic for Michie Phone.	Amplified base set for above. Mounted in Pelican cases at about 500g per set.	~AUD 500 /set Volunteer designed and built. Only 20 sets built to date…	Used by NZ, and each Australian state except Victoria. Excellent, but limited numbers. A group of nerds is attempting to design new versions to carry digital data.
CTS Phones ERG1226 V2	Italy	2010	Developed by the Technical Speleological Commission of CNSAS	Self-powered phone handsets for full-duplex communication via telephone wire. Details below.	150 - 180 €	Reference product, in use by CNSAS. A new version with some optimizations is under development.

Name	Country of Origin	Date	Outline	Description	Costs	Status
Ermes	Italy	2024 (first version 2016)	Developed by the Technical Speleological Commission of CNSAS Patent no.: 202024000003646	Data transmission system between cave interior and exterior with internet connectivity from inside the cave. Details below.	Approx. 6000 €	Product marketed by BPG Radiocomunicazioni Srl
UGCAT1	Bulgaria		Semi duplex analogue transceiver.	Uses Push to Talk (PTT) button with "Auto Wake-up" function in transmit mode. Automatic control of the output level of signal for maximum communication distance.		In use in Bulgaria. Used in Morca Turkey rescue.
UGCBRF	Bulgaria		Multiband UHF audio repeater	Radio frequency wired telephone		In use in Bulgaria.
SPL+	France	2024	Developed for Speleo Secours Francais	Self-powered wired phone (3x AAA). Unlimited number of telephones handsets over a very long distance (10 km)	149 €	In use in France
SPL+ PC	France	2024	Developed for Speleo Secours Francais	Telephones handsets in Pelicase box for use at the command posts	397 €	In use in France
Dataphone	France	2024	Developed for Speleo Secours Francais	Local VDSL internet network over twisted pair cabling, 3 km long. Wi-Fi access points are permitted at both ends, and a router is allowed on the surface end for web routing. Enables data communication, such as video conferencing, from the cave to the internet.	1080 €	In use in France
Ether (Radio-Telephone Link)	Italy	2025	Patent Date June 9, 2025	Engineered to address the critical need for direct point-to-point communication between the Operations Direction and the technicians operating inside a cave/subterranean environment.	Unit Cost: €6,800	Operational (currently deployed at national and regional levels)

Wireless Radio Devices

Devices still used by rescue teams. Some are out of production.

Name	Country of Origin	Date	Outline	Description	Costs	Status
Cavelink V2	Switzerland	2003	Ingenieurbüro Ziegler GmbH Developed by Felix Ziegler.	Initially developed for work in the Holloch and extended to use in cave rescue.	ca. Euro 1000 with battery & antenna	Problems getting replacement parts.
Cavelink V4	Switzerland	Planned 2024	Ingenieurbüro Ziegler GmbH Developed by Felix and Simon Ziegler.	The next generation of Cave-Link. In addition to all the functions of Cave-Link V2, see description below.	ca. Euro 1100 / pc with battery & antenna	In development; planned availability 2024
Nicola 3	Britain	2000/2010	Development lead by Graham Naylor. Long development period.	Used linear aerials; best performance was 1 kilometer in Peak Cavern. Design requires commercial build.	Greater than £1000 per end estimate.	Some parts may be obsolete. Cost relates to small build quantities.
Nicola 4	Britain	2025	Development lead by Graham Naylor.	Aims to support audio and text communications. See description below.	See below.	In development.
µHeyPhone	Britain	2017	This is the HEYPhone re-worked.	Re-worked for 2010s technology and aimed at 'home' construction. Designed by Ian Cooper and published in the CREG Journal **103**, p12. September 2018. (PDF 278KB). Again reworked 2023 for obsolete parts and publication of redesign in CREG Journal 126 (June 2024).	n/a	Home build. Reworked version published June2024 and believed can still be built.

Name	Country of Origin	Date	Outline	Description	Costs	Status
Pimprenelle {Pimpernel)	France		Developed in France	See below.		
Drummond Transverter	Canada	1992	Developed by Ian Drummond of the Alberta Speleological Society to reduce the time of construction.	Device is obsolete but still in use in several locations. The maker is still able to repair units. Contact via the Alberta Speleological Society	Not applicable in 2023.	Obsolete – out of production; But still in use
xFerra	Russia	2020		To be determined http://www.xferra.com/products/ Need to contact for pricing.	tbd	Commercial offering.
QDX-M (Cave Variant)	Türkiye, Canada, USA, (app from Australia)	2023-2024	Commercial QDX-M digital transceiver kit by QRP Labs [(https://qrp-labs.com/qdxm.html] (designed by Hans Summers and manufactured in Türkiye), with hardware mods for 2200m band by Ian Drummond & variations by Brian Pease.	Very small, light, digital radio which uses direct waveform synthesis Tx and integral ADC/DSP Rx to facilitate two-way text communications (no voice). Must be used together with a cell phone (or laptop) as the terminal device / UI, and a USB B-C cable to connect the two. See below	See below for details	Deployment commenced in 2025 in Canada cave rescue, although extent of capabilities still not fully tested in the field and work continues to optimize rugged packaging

Mesh Radio Systems

This category is added in 2026.

Name	Country of Origin	Date	Outline	Description	Costs	Status
SPELLCOM	Poland	2023	Commercial product developed by SYBET in cooperation with the SGRJ and GOPR rescue groups.	Suitable for all-sized caves. Bigger chambers and longer the corridors require fewer nodes. It is based on MESH technology. The system also enables wired node connections for complex and narrow passages.	Need to contact for pricing	Commercial, offering.
Meshtastic	USA then others	2023 and ongoing	Open source project with different flavours in the projects described in the narrative below.	Mesh networked radios tested successfully in a number of different projects. Note the costs excludes mobile phone or similar used as operator interface.	Varies but typically sub €100 per radio	Work is ongoing but a working system could be implemented

Detailed Descriptions - Wired

CAVE-SYS

CAVE-SYS system designed to provide voice communication in confined spaces. CAVE – SYS is a light version of MCA-1000 system to underground communication in mining industry.

See: https://tranztel.com.pl/our-solutions/mca-1000digi/?lang=en .

Leaky Feeder Cable technology. Special coaxial cable (thin and flexible, diameter 9mm, weight 5kg/500m) works as distributed antenna and provides radio coverage on VHF band (e.g. 139MHz) to handheld radios in range of LFC radiation (depend of underground structure, a few dozen meters. On surface (or another supervisor place) base station is located, one LFC segment (without any active device) can be length up to 400-500m. To expand length of LFC can be use special RF bi-directional amplifiers).

In addition, can enable a video streaming service to surface from special WiFi module at the end of LFC (tested only with one 300m segment of LCF).

Leaky Feder Cable to CAVE-SYS has been specially designed and manufactured by Bitner Cable Manufacturer.

Base station internal 12V rechargeable battery (to 3-4 hours lifetime). External power supply 230VAC/12VDC. Handheld radios battery (to 12-14 hours lifetime).

2015-2017 the cost of the system was approx.: 6000 EUR (basic configuration: base station (voice only), 4 pcs of handheld radios, LFC 300m length).

Ex-Heulruf-Telefon (howl-call telephone)

Developed for mining.

Twisted pair wired device without amplification.

No power supply (sound-powered telephone system with dynamic transmitter and receiver capsules)

Call signal is generated by turning the rotary knob with an audio frequency dynamo generating a 2000Hz signal.

direct connection to base and other call stations

Max Distance: theoretical 10km, we use up to 200m without problems, gets very quiet over greater distances (no amplification)

Call station can attach to any point of the cable with Pricker-pliers.

May be available here: https://www.satcomglobal.com/fhf-ex-howl-call-solund-powered-mining-telephone or on EBay.

Transistor Intercom 2-way

Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.

Obsolete – out of production. Open source

Twisted pair wired device. Based on a door intercom system from apartment building with modifications. Adapter to Fernsig plug (howl-call telephone) is available.

Based an old (1960-70s) intercom system. Was bought and modified in 2003 by Hartmut Simmert. Was developed for smaller, dry caves <100m in Saxony. Used by caving club “Höhlen- und Karstforschung Dresden e.V” and Cave Rescue Saxony until now.

- 1 base station and 3 call stations.
- Call stations: call button and speaker (=microphone)
- Base station: can change between 3 channels, call button, speak button, volume adjustable
- The call stations cannot call/talk to each other directly!
- Power supply: 6x1,5V AA Batteries
- Max. Distance: >200m (more was not tested)

Call stations are robust and resistant to cold and humidity but not suitable for permanent installation in a cave.

Contact manufacturer Hartmut Simmert via Höhlenrettung Sachsen:

- Lisa Hoffmann at hoffmann01@t-online.de

CTS PHONES ERG1226 V2

With the aim to address the commercial discontinuation of the industrially produced FAVA phones that CNSAS had been using for years, the Technical Speleological Commission of CNSAS designed a new phone device.

The design covered both the electronics and the plastic shell. The new phone maintains compatibility with old phones and is completely waterproof, with an extremely competitive production cost.

Production and commercialization have been entrusted to Ergotronica Srl.

While in standby mode the device consumes no electrical power to preserve battery lifespan. To listen and speak, the electronic circuit must be powered on by pressing a dedicated button. If the phone is used in a noisy environment, the "call received" function can be activated by modifying the PCB, causing the green LED to light up when the phone Is called. The light stays on until the user responds. The phone indicates low battery by lighting up a red LED.
The battery can be accessed without specialized tools, simply by using a standard washer normally included in a standard hang fix.

The phone is optimized to work connected to a standard telephone wire (2 x 6/10mm) and features crocodile clips with piercing needles, allowing connection at any point along the wire without the need to manually strip the cable.

ERMES

The Ermes data transmission system was designed and developed to enable video calls, transmit health data via multi-parameter monitors, share ultrasound images, and much more, particularly in support of the medical team working with the injured person in caves or other confined spaces.

If an internet connection (4G, Satellite, Starlink, etc.) is available outside the cave, Ermes brings connectivity inside, and all devices that connect to the Wi-Fi network generated in the cave can browse as if they were connected to any external internet service.

Medical personnel working on the injured person can make video calls, share data with colleagues and specialists worldwide, and access all web services. This allows for consultations with specialized medical staff who, from anywhere, can support the speleo-medical professional operating in the cave.

Ermes is professionally designed thanks to high-efficiency, reliable industrial devices. The development and marketing of the system have been entrusted by CNSAS to BPG Radiocomunicazioni Srl, a company leader in the communication sector.
For data transmission, Ermes uses the standard telephone wire (2 x 6/10mm) commonly used for voice communication via the CTS Telephones ERG1226 V2, establishing a VDSL connection over the phone line.

Ermes consists of two waterproof and shock-resistant cases:

- A smaller case is brought into the cave and connected to the telephone wire near the location where connectivity is needed.
- A larger case is placed at the cave entrance, physically connected to the telephone wire.

Inside the cases are situated all the necessary devices and batteries to make the system autonomous and independent. Simply connect the telephone wire and turn on the system to start the Wi-Fi connection.

The external case integrates a 4G dual SIM router that automatically connects the system to the internet if a phone signal is present. If not, there is a WAN interface to connect Ermes to an external network (e.g., Starlink).

The first working prototype of Ermes was developed by the Technical Speleological Commission of CNSAS in 2016, and cave testing demonstrated the feasibility and future potentiality of the system. The final pre-production professional version of Ermes was produced by BPG Radiocomunicazioni Srl in January 2024, and throughout that year, ERMES was used and tested in various operational conditions during CNSAS real simulations, always with excellent results.

The most complex drill in which Ermes was tested took the device 2400 meters away from the cave entrance, and the quality of the connection between the interior and exterior of the cave was good along all the line, with a successful pass of each one of the connectivity tests.

The signal degradation curve suggests that Ermes could be used up to around 4-5 km of telephone wire.

The system was tested with several medical devices, including:

- CERBERO UPROBE-L5C Ultrasound
- Schiller Touch 7 Defibrillator Monitor
- D-Heart ECG
- CNOGA Finger Multiparameter Monitor

In 2024, CNSAS filed a Utility Model Patent for the Ermes system (Italian Patent no.: 202024000003646).

SPL Plus (SPL+)

The SPL Plus was developed as a continuation of the SPL05, which it is gradually replacing/complementing in our operational setups.
It comes in the same casing as the original SPL05 while offering significant improvements.

The main improvements:
- Audible beeps at the start and end of transmission.
- Powerful LED indicator flashing every 5 seconds, also providing a precise battery level indicator.
- Incoming call indicator light
- Integrated ADSL filter for interoperability with dataphones.
- Tropicalized electronics.
- Line continuity check function

And in continuity

- Same power supply as SPL05 (3x AAA)
- 100% compatible with SPL05

https://www.speleo-secours.fr/systeme-filaire/

The SPL+ PC

The SPL+ PC was developed as a continuation of the SPL+, which is gradually replacing/complementing the SPL 05 in our operational batches.

It comes in a Pelicase box similar to that of the Pimprenelle, clearly marked.

This terminal unit is designed for use with command posts (PCs) and offers a highly ergonomic interface with functions tailored to rescue management needs.

Its main features:
- Line connection via banana plug or wire clamp
- Unit with a high-capacity battery that can be connected to an additional battery via a standard SSF connector (same as the Pimprenelle unit).
- Battery charge indicator via LED
- The integrated battery charges with the same charger as the Pimprenelle lead-acid gel batteries.
- Integrated, oversized 70 mm speaker (adjustable volume), which can be disabled.
- Detachable gooseneck microphone allowing optional connection of:
- A TPS-type microphone (transmit/receive)
- A headset (transmit/receive)
- SPL-VHF radio interface via a dedicated cable (replacing the BIP unit used with a Pimprenelle unit)
- Self-test function Line continuity testing by the installation team (ground-to-surface control).
- Surface-to-ground line control function associated with an SPL + "Ground" station.
- Integrated ADSL filter for Dataphone compatibility.

Weight: 1.25 kg
https://www.speleo-secours.fr/systeme-filaire/

Dataphone

First prototype done in 2022; production from 2025
Developed by Olivier LANET for Speleo Secours Francais.

Local VDSL internet network over twisted pair cabling, 3 km long.
50Mbps at 1000m, down to 10Mbps at 2000m and less than 5Mbps at 3000m with 5/10mm wire.

Wi-Fi access points are permitted at both ends, allowing connect phone cell or computer.

A router is available on the surface for web routing.

Enables data communication, such as video conferencing, from the cave to the internet.
It is possible to use WhatApp, Signal on any application that user already have on his phone.
Some mobile phones allow WiFi calling, so it is also possible to be called by anyone from a standard cellular network on the other side of the world!

https://www.speleo-secours.fr/dataphone/

Ether (Radio-Telephone Link)

The system was engineered to address the critical need for direct point-to-point communication between the Operations Direction and the technicians operating inside a cave/subterranean environment, specifically when the base camp is situated at a significant distance from the cave entrance.

Historically, this logistical challenge was managed via two suboptimal methods:

1. External landline deployment: manual laying of telephone lines across surface terrain, which is susceptible to topographical obstacles, mechanical failure (wildlife or human interference), and lightning strikes.

2. Forward relay stations: Establishing a manned forward camp near the entrance where a technician acts as a human bridge between the cave telephone and the radio operator. This "filtered" communication often results in data loss or misinterpretation due to third-party relaying.

System Architecture and Operation

The Ether system is housed in a compact, lightweight, and IP-rated waterproof rugged case. The external interface features a power switch, an RF antenna connector, telephone line terminals, and a dedicated DC charging port.

Key Functional Features:

End-to-End connectivity: upon activation, the system establishes a direct link between the subterranean telephone network and the digital radio assigned to Operations Direction.

Full-duplex communication: unlike standard Push-To-Talk (PTT) radio, the system supports simultaneous bidirectional audio, mimicking standard telephony.

Signal integrity: the radio operates as a mobile handset, receiving and initiating calls via an integrated ringer (buzzer).

Security: transmission is fully encrypted, ensuring data privacy and operational confidentiality.

Power management: high-capacity internal batteries provide significant operational autonomy, which can be further augmented via external auxiliary power sources.

RF optimization: to maintain high quality of service and prevent packet loss during digital transmission, each kit includes low-loss coaxial cabling with specialized connectors, high-gain vertical antennas, portable tripods for rapid field deployment.

Overview – Wireless

Radio Frequency

For the most part, wireless cave radios operate at low frequencies typically below 100 kHz.

Users must be aware of the limitations in their country and any regulations that apply.

It was noted at the conference in Wojcieszów, the regulations in Poland were more restrictive and we needed to change the Nicola 4 frequency.

Loop Aerials

Early wireless radios for example the Miolephone used loop aerials.

Loop aerials comprise a length of wire looped and tuned to the radio concerned. They are compact and easily deployed for example when there is limited space or ground conditions make linear aerials difficult to deploy. They do not however offer the range of linear aerials – typically 200 metres.

The early loop aerials were constructed using ribbon cable, but modern developments have used much thicker cabling and do seem to be getting better results (maybe 300 metres), although still not matching that of liner aerials. Further work is needed here.

Linear Aerials

Linear aerials comprise a pair of wires connected to the radio and earthed at the other end. This allows the radio to inject a signal that can be received by other radios at a distance.

The earth is achieved by spikes of some form pushed into the ground. The earth needs to be good to get a good signal.

With linear aerials of sufficient length, communication has been made at a distance of about 1km.

Detailed Descriptions - Wireless

Pimprenelle {Pimpernel)

The Pimprenelle development was started in March 2008 by Rafael Chevalier.

First prototype was ready by July 2008, but complete development took a little longer.

First batch of production was released in 2014.

Main features:

- Compatible with Nicola devices (using same frequency and same range)
- Allow connection to SPL wired system and UHF/VHF radios
- Waterproof construction
- Easy to use (plug and play)
- Easily upgradable
- Digital modulation / demodulation
- Powered with an external battery (Lead acid or LiFePO4)
- No boot time (instant turn-on)
- Parrot mode allows automatic transmission of previously received message (not exceeding 20s)
- External shoulder mic/PTT or headphone wired through waterproof connector

Like other cave radios, it uses 2 earthed electrodes in contact with the cave limestone.

It uses a carrier frequency of 86.9KHz with SSB or FM or AF modulation.

Transmission of text/data will also be possible in the near future

More information at https://www.speleo-secours.fr/les-systemes-tps-transmission-par-le-sol/

CaveLink

Cave-Link V2

Refer www.cavelink.com. Cavelink 2 is now out of production.

Can be used in three configurations:

- Single wire device
- Twisted pair wired device.
- through the earth device

An Interface for GSM SMS at the surface is available.

Communicates via text messages only.

Like all through the earth devices the maximum transmission distance for Cavelink is also dependent on antenna length, weather (thunderstorms), and the time of day. Cavelink repeats the data until it arrives correctly. Bad conditions prolong the transmission, but there are no errors. In the Hölloch cave we have several links with about 1000m distance, over which data is transmitted every 4 hours.

Cavelink was developed in 2003 and the first devices were used for data transmission from a cave for monitoring measurements during tunnel construction near the cave.

The devices with interface for GSM SMS were also used for text messages at rescue operations. Each device can also serve as a repeater and forward messages. Thus, very large distances can be overcome.

In 2010 the device was completely revised (Cavelink V3).

The focus was always set on minimum power consumption, so the device with the internal battery can be in operation for several days (continuous operation) to months (depending on the interval of transmissions).

There are many additional devices like GSM interface, loudspeaker, printer, measuring boxes for water level, temperature, CO2 etc.

Until 2019, about 200 devices have been built and are standard in many rescue organizations.

Cavelink 2 is not open source, but if someone is interested in the schemes or the source codes, they can get in touch with the manufacturers.

Cave-Link V4

Refer www.cavelink.com. Cavelink 4 is in development.

Can be used in three configurations:

- Single wire device
- Twisted pair wired device.
- through the earth device

An Interface for GSM SMS at the surface is available.

The next generation of Cave-Link. In addition to all the functions of Cave-Link V2, new functions will also be added:

- Speech transmission with wired connections (single wire and twisted pair wire).
- Interaction with Nicola devices. (Receiving Nicola communication already works).
- Transmission of digitised speech via data communication through the earth. Forwarding via multiple stations to bridge long distances.
- Bluetooth and Wi-Fi for integration of mobile phones. For example, to transmit forms or pictures.

Both transmitter and receiver are completely redesigned for these new functions. The housing and the battery have also been revised.

The new Cave-Link V4 is operated via a 4.3 inch resistive touch screen. A stylus is integrated directly into the case. The device will be compatible with older Cave-Links and their additional gear.

The device is in a first prototype status. Completion of the project is pending.

Cavelink 4 is not open source, but if someone is interested in the schemes or the source codes, they can get in touch with the manufacturers.

Nicola Radios

Nicola 3

With the HEYPhone and Nicola 2 coming to the end of their life span, Nicola 3 development began in 2007 by Graham Naylor in the UK and supported by the British Cave Rescue Council.

Initial development used a Spartan 3 FPGA (https://www.xilinx.com/products/silicon-devices/fpga/spartan-3.html) to offer more functionality that previous discrete radios. Later in the design process, this changed to a Zynq FPGA but this still had limited onboard memory and no ethernet connection making the development process difficult.

In the end, the development took much longer than planned and the end product required a professional build. This put the cost too high for most organisations, The BCRC was able to run a batch of 80 radios for which it negotiated a good price and these as in use by some teams.

Nicola 3 used a speaker/microphone wired in through a connector and had internal batteries. It supported Bluetooth meaning a BT headset could be used in place of the handset.

Being programmed meant the frequency could be changed. The default was set to 87 kHz for the UK and to 86.5 for France. A menu system allowed this to be changed in the field.

Some information can be found at https://www.caverescue.org.uk/nicolaradio/ .

Still in use by some teams in Britain.

Nicola 4

Testing (March 2025) has Nicola as a working cave radio.

Nicola 4 is the progression from Nicola 3 where many lessons were learnt. This radio uses a Cora Z7 (https://www.xilinx.com/products/boards-and-kits/1-1qlaz7n.html) which offers a considerable step up in capability compared to the Zynq used in Nicola 3.

The much increased RAM memory together with an onboard ethernet connection allows an embedded Linux system to be used. This has made the development process much easier.

The radio offers:

- Audio communication with an internal microphone and speaker or a Bluetooth headset/speaker
- Text messaging similar to that on a mobile phone. Multi language support is included (but remains to be fully tested).
- A touch screen is used for control and for text messaging.
- Testing is using earthed aerials to give a communications range of up to 1 km
- Uses external batteries of 12 to 36 volts (in development we are using 4 by 18650s giving 14.4 volts)

One of the main aims in the development is for easy manufacture of the radios. During development, the circuit boards have been produced by a professional company and these have been populated by Graham using a hot-plate soldering mechanism. The packing in suitable casing is then done by the developers.

The construction does require moderate skills, meaning not everyone will be able to do the builds. But it is expected rescue organisations would be able to find appropriate personnel to carry out the work and thus keep the costs under control.

The design and software will be in the public domain at an appropriate point. With the Bluetooth interface, the device could then be connected to other BT devices for example use in data collection. This is a futuristic option.

Updates available at https://www.facebook.com/AssociationNicola .

Prices have gone up since earlier estimates. A review of the pricing is:

- Cora Z7 - £140
- Nextion 5” screen - £60
- Nicola 4 PCB - £150 estimate
- Battery - £35
- Sundries include boxing, cabling etc - £100

Giving a price of about say £500 (€600) (March 2026).

The cost of manufacture will depend on the method used. ‘Home’ manufacture requires sufficient skills to build the proprietary circuit board and some dexterity to put the radio together.

It will be possible to get the Nicola 4 company built but this will add costs. For this a sufficient volume of production would help keep the costs down.

Meshtastic – at a CREG meeting in the Yorkshire Dales in October 2025, the Meshtastic radios were demonstrated. A discussion followed and it was decided to attempt to link the Nicola 4 radios to the Meshtastic net. To cut the story short and at the time of writing, we have a working connection between the radios where messages can be sent in both directions. This remains to be tested in cave conditions and indeed it is expected further development work will be required. See the full description of Meshtastic radios below.

March 2025

The internal microphone/speaker has been replaced by a traditional handheld microphone/speaker. This immediately gave a much better performance.

Successful testing in Kingsdale Master Cave (KMC) in the Yorkshire Dales and in Peak Cavern in the Derbyshire Dales with good audio and text messages exchanged. Reports are available.

The radios are now deemed working although there remains some work to be done. This includes documenting the radios, including how to build the radios.

March 2026

The radios were successfully demonstrated at the BCRC AGM April 2025 and at the BCRC Conference in June 2025. However, there was a request to change to a larger 5" touch screen and this coupled with the selected 3½ inch screen going out of production caused this change to go ahead.

It has taken considerably longer than planned to get the re-worked radios ready, noting that the build of these radios is being done by the BCRC (not the developers) and thus should allow a third party construction manual to be produced.

We are intending to again demonstrate at the BCRC AGM in April 2026 then move to team testing in May.

QDX-M (Cave Variant)

A text messaging cave radio using components and software from the amateur radio world developed in Canada (Alberta) with additional support. The primary component is the QDX-M transceiver from QRP Labs (https://qrp-labs.com/qdxm.html) which must be purchased as a kit since specific modifications are required. A battery power supply and voltage regulator are also required; kits can be built for either a 9v or 12 v supply. The QDX-M is modified to operate at 137.5 kHz which corresponds to the digital portion of the 2200m amateur radio band. (check OK to operate in your country).

The QDX-M is connected to an Android mobile phone or tablet as the user interface via a USB B-to-C cable.

For Android cell phones or tablets, use open-source RadioMsg app by John Douyere. See https://bitbucket.org/VK2ETA/radiomsg/downloads/ .

The radio supports a variety of single-tone FSK modes such as JS8, Olivia, Thor, Throb, etc. (trading off sensitivity for data rate) and can also be used for testing using some WSJT-X modes such as WSPR, if a laptop is used as the interface.

See CREG Journal, 124 (Dec 2023) and 128 (Dec 2024) for details.

Tested with loop aerials to date, under optimum conditions a range of 6 km has been achieved on the surface and is expected to normally exceed 1 km. Through-rock range successfully tested at ~600m and

the RadioMsg app includes an ability to automatically relay between stations, thus extending potential range. It has not been tested with earthed electrodes. Approximate costings are (March 2025):

- The QDX-M is $65 USD as a kit but it is recommended to add the proprietary box at a further $20 and the 2.L power plug at $1:00. Further additional parts would make the cost about €100.
- Loop aerials and frames, cables etc., say a further $60 (for simplicity say €60)
- Battery and voltage regulator say €40
- Android mobile phone or tablet. This could be a second hand refurbished model as long as it is running Android 7 or higher. A Galaxy A03 phone can be obtained in the UK for less that £100 (again for simplicity let us say €100)

Giving a total of €300. Add to this items such as battery chargers, carrying cases etc.

But beware these are approximate based on the developer's experience.

As you might see in the table entry, significant successful testing has been undertaken in Alberta/British Colombia (Canada) and the radios are now being supplied to the cave rescue teams in those provinces.

Detailed Descriptions – Mesh Radios

SpellCom - Wireless/Hybrid Communication System for Caves

SpellCom is a purpose-built wireless/hybrid communication system designed for natural caves, tunnels, and other complex underground environments where traditional infrastructure is impractical or unavailable. It has been developed in close cooperation with experienced field operators and is used by cave rescue teams in Slovenia, and Croatia, proving its reliability in real-world scenarios.

The system creates a self-forming mesh network using compact, battery- powered MiniNodes and rugged mPhones, enabling robust, wireless communication between underground personnel. MiniNodes are significantly smaller and lighter **(only 250g)** than the BatNodes used in mine rescue systems, making them ideal for scenarios where mobility and weight are crucial.

No cables, amplifiers, or external infrastructure are required, making deployment fast and flexible even in rough terrain or during emergencies. **If required by the terrain, nodes can also be interconnected with a cable to maintain reliable communication coverage**.

Rescue team leaders can monitor and manage the network via a laptop running SpellCom software, which provides real-time **tracking** of personnel, communication status, and battery levels. With the latest software update, users can now **upload cave maps**, track individual rescuers more clearly and accurately throughout the mission.

Thanks to its standby mode, MiniNodes can remain operational for up to **three months** in low-power mode, while standard operation allows for about **2.5 days** of active use. Whether coordinating a rescue mission or guiding a research team, SpellCom ensures stable communication, enhanced oversight, and operational confidence underground.

System Components:

MiniNode (Battery Radio Nodes)

Battery-powered radio nodes that form a wireless mesh network underground. Deployed wherever needed to extend or strengthen the signal.

mPhone (Radiotelephones)
Rugged radiotelephones for team members underground. Enable real-time communication, user identification, and location tracking within the network.

SpellCom Software (Laptop-based)

Central command software that enables surface controllers to manage the network, track devices, monitor system health, and visualize positions on uploaded cave maps.

Why Choose SpellCom?

- Designed specifically for cave and tunnel rescue operations
- MiniNodes are smaller and lighter than BatNodes, improving portability in tight spaces
- Fully wireless, quick to deploy, and easy to expand
- If required by the terrain, nodes can also be interconnected with a cable to maintain reliable communication coverage.
- Real-world proven by European cave rescue teams
- Advanced tracking and coordination tools built into the software
- Minimal maintenance, highly adaptable, and infrastructure-free

For more details please visit: https://sybet.eu/systems/spellcom/ and https://sybet.eu/devices/.

Sybet International Catalog with all our products available here (SpellCom – page 6):
https://drive.google.com/file/d/1W6sourouzR--p2iJUqZ2xsOWiuLsD2fF/view?usp=sharing

Have a question?
We typically respond to emails within 24 hours. For urgent inquiries, please call us.

Email: sales@sybet.eu

Phone: +48 603 487 009

The website is at https://sybet.eu/spellcom/ .

Meshtastic for Underground Communications

Meshtastic Overview

Meshtastic is a community-driven radio system built on affordable open-source hardware that enables long-distance communication without cellular or internet infrastructure. Using open-source LoRa technology, it trades data rate for reliability and range through configurable features such as Spread Factor and Forward Error Correction. Additionally, the mobile app is well supported on iOS and Android and can easily be connected to any radio over low-energy Bluetooth (BLE). The system runs on low-power microcontrollers such as the ESP32 and nRF52840 with common LoRa modules operating in license-free ISM bands under regional power limits. The Meshtastic global developer community has expanded its use from recreation to emergency response, with typical ranges of 2–5 km above ground. Encryption, long battery life, GPS sharing, and integration with tools such as ATAK and CalTopo make Meshtastic a versatile platform for rescue operations.

Adaptation for Underground

Subterranean environments such as caves present severe communication challenges making reliability difficult with radio systems. Meshtastic is increasingly attractive in this context because it is far less expensive than through-the-earth radio systems (with compatible hardware available for €30-50) and possibly faster to deploy than traditional wired communications. Its user-friendly setup and mobile app support allow rescuers and volunteers to operate radios quickly with minimal training, while self-organizing mesh behaviour and low power consumption support rapid deployment and extended battery operation in remote environments. However, the stock Meshtastic limit of seven hops can severely restrict usefulness in caves where networks often form long linear chains. While mesh networking underground shows strong potential, significant technical hurdles remain, driving community efforts to improve reliability and adapt Meshtastic for effective underground use. The table below highlights major efforts to adapt Meshtastic for cave rescue communications.

See also Nicola 4 radios above where a connection between the Meshtastic radios and Nicola 4 is discussed.

A more detailed explanation of the Meshtastic radios can be found ECRA-Communications-Meshtastic-1.00. Note this a 17 page document.

System Name	Vangelis	FLAMINGO	Red Meshocan
Associated Organization(s)	Gloucestershire Cave Rescue Group (GCRG) Gloucestershire, UK	Huntsville Cave Rescue Unit (HCRU) Huntsville, AL, USA	Fundación Espeleosocorro Cántabro (ESOCAN) Cantabria, ES
Start Date	October 2023	March 2025	November 2025
Summary	Initial experimentation into underground Meshtastic, discovering higher performance over PMR.	Adaptation of Vangelis to further optimize performance, setup process and incorporate RS485 bridge.	Investigating Meshtastic for connecting Advanced Command Post (PMA) to cave for rescue operations.
Key Technologies	• Hop decrement removal to overcome hop limit • Node placement methodology using RangeTest pings to optimize spacing	• Hop limit expansion to 255 (preserving Direct Messaging) • RS485 bridge for wired comms • Hands-free setup mode • Batch radio configuration (including pre-programmed encrypted Channels) • Configurable retransmission counts • 18650 li-ion battery	• Above-ground relay node for reaching from cave entrance to PMA • Custom waterproof enclosures • Documented radio setup procedures
Hardware Implementation	• TacMesh radio units	• Cavenode V2 (Custom, with buzzer) • Hybrid V2 (Custom, with RS485 bridge) • WisMesh Pocket (with optional buzzer)	• IP65 relay node (Custom) • LilyGo T-Deck • Miniature Team Leader node (Custom) • Phone & radio combination enclosure
Core Electronic Hardware	RAKWireless RAK4631	RAKWireless RAK4631 With RAK5802 RS485 Module (Hybrid V2's)	Heltec V3 LilyGo T-Deck
Frequencies Tested	868MHz LoRa 2.4GHz BLE	915MHz LoRa 2.4GHz BLE	868MHz LoRa 2.4GHz BLE & WiFi
Field Testing	Forest Dean Caves & Emmer Green Mines (UK, Feb-Mar 2024) • Chain of up to 10 nodes demonstrated • Evaluated performance through climbdowns and squeezes >5m Additional Testing (UK) • Evaluated 2 and 3 dBi antennas • Determined tight passages limit range • Larger tunnels can enable >100m range	Guffey Cave HCRU Class (AL, USA, Aug 2025) • Network of 20 nodes • Hybrid topology with 2x (>90m) wires HCRU/CHCRS Mock Rescue (AL, USA, Sept 2025) • Network of 23 nodes (1.4 km deep) • Hybrid topology with 3x (>200m) wires • Utilized during vertical rescue exercise Tumbling Rock Test (AL, USA, Jan 2026) • Reached 1.4km with 15 mixed nodes	Lanestosa Exercise (Karrantza, ES, Nov 2025) • Exchanged messages from inside mine to dislocated PMA • Upgraded antennas to reduce node quantity by 40% • Utilized LilyGo T-Deck signal scanner to aid in node placement

		• 16 hops achieved	
Estimated Cost/Weight	€55 per radio <150g per radio	€35 per Cavenode V2 radio €40 per Hybrid V2 radio <160g per radio (4kg per field kit) 10L hard case for field kit	€40 per custom node €100 per T-Deck <180g per relay node 73g per rescuer node
Performance Specifications	RF Range: 20-120m Endurance: 6-7 days (at 12°C)	RF Range: 40-100m Wire Range: 3km Endurance: 10 days (down to 0°C)	RF Range: 2.5km (surface only) Endurance: 1-3 days (T-Deck)
Deployment	N/A	• Cavenode and Hybrid field kits delivered to HCRU • Development package sent to Hrvatska Gorska Služba Spašavanja (HGSS/Croatian mountain rescue service)	N/A
Future Work	• Investigate Spread Factor optimization • Investigate through-the-earth comms • Investigate voice comms over LoRa	• Improve Incident Command logging tools • Further streamline setup process • Improve/ruggedize enclosure design • Adapt for expedition caving (semi-permanent)	• Investigate additional RF topologies to connect to PMA over long distance • Investigate using MQTT for “Advanced networks” for long-distance PMA’s • Explore MeshCore • Investigate geographic overlay for situational awareness
Website	github.com/semper-ad-fundum/vangelis	github.com/rbreesems/flamingo	espeleosocorro.es/red-meshocan-de-comunicaciones-inalambricas-en-cavidades/

Detailed Descriptions for Obsolete Devices - Wireless

Molephone

Developed in the 1980s, this proved to be amongst the first effective underground communication devices not needing a wire to be run into the cave. It operated by a modulated magnetic signal using loop aerials. This meant the range was limited. Hearsay reports that a depth of 300 metres has been achieved in Spain. A more typical depth was some 100 to 150 metres.

The radio was robust enclosed in a diecast box and using a handheld microphone speaker. The device was powered by external batteries that could easily be changed under operational conditions.

The radio was capable of locating underground survey stations and this was used by the Cave Rescue Organisation (CRO – www.cro.org.uk . Finding these locations in the fog on a wide flat moor and on a cold winter's night required precise navigation! The device was used by the British cave rescue teams up to the early 2000s when the HEYPhone became available. The lack of depth was not an issue.

Ogofon

Developed in the 70s this followed the Molephone using a 1m diameter loop antenna. Initially a many turn ribbon cable but later a heavier 5 turn cable.

The frequency of 87.5KHz USB was chosen as this seemed to have less interference

It has 3 modes of operation:

- RECEIVE
- PIP TONES
- CONTINUOUS TONE

The ptt switch is on the microphone.

PIP TONE This is identical to RECEIVE but every 3 seconds or so a short 'pip' is transmitted. Speech is also possible when signals are strong. This mode allows both stations to have confidence that the communication link is being maintained and is useful for initial location by the surface party.

CONTINUOUS TONE A tone is transmitted by the unit for the purpose of direction finding. No speech is possible in this mode.

Still in use in Germany.

Nicola 2

Nicola radio development began in the 1990s with the experimental Nicola 1 and led to the production of Nicola 2, used initially by teams in the Spéléo Secours Français (SSF) and later by a wider audience. This device used linear earthed aerials (compare with the loop aerials of the Molephone) and could communicate over distance s of 1 kilometer. The device used a handheld microphone/speaker and used external batteries. The radio was enclosed in a robust diecast box. It operated on a frequency of 86.5 kHz and whilst it would communicate with the HEYPhone there was a "Mickey Mouse" effect on the voice.

TEDRA

In 1998 the University of Zaragoza started a research project to design a radio-location system that later evolved into a communications system. Once the foundations were laid, Siemens bought the patent and developed the system. It was launched on the market in 2007. As a result of low profitability and a small market, Siemens itself abandons the product.

A device that enables wireless communications to be established between underground and above ground environments. Tedra devices (Through Earth Digital Radio Appliance) do not require a wire connection between the points to be communicated and also have different benefits derived from their short installation time, light weight and mobility.

Each Tedra device integrates a pair of electrodes that are inserted into the ground and which are connected, in turn, to the electronic transmitter-receiver equipment. In the underground environment, it will be enough to correctly distribute the contact stakes or meshes to be able to put this new communication system into operation.

Now out of production but still used in Spain (April 2024).

Drummond Transverter

The transverter is driven by a commercial CB radio (usually SSB).

1m square loop antennas at 185 kHz are most common, range usually 4-500m. Range up to 700m using asymmetric loop antennas (see attached documentation). Power is usually 12V, 7AH gelled lead-acid battery which was adequate for 15 hours service as the surface unit during one rescue. Device is voice (SSB) and can provide pulsed tone for location work.

Device is very flexible, it can change frequency, change mode of operation (SSB, FM, AM). The standard 50 Ohm output allows use of many different antenna types and sizes. An important feature is the ease of use of the CB radio interface. A few minutes instruction and anyone can reliably use it.

Device is open source.

Initially published in Speleonics No.19 in 1993.

References:

1) Converting CB radios for use as low-frequency cave radios, Ian Drummond, Speleonics, 19, May 1993, p3-8
2) Further developments with the CB Transverters, Ian Drummond, Speleonics, 19, May 1993, p9
3) Update on CB transverters for cave-radio use, Ian Drummond, Speleonics 20, Feb 1994, p2
4) CB transverter goes FM, Ian Drummond, CREG J,21, Sep 1995, p7.
5) Going Deeper – two ways to improve performance. Ian Drummond and Bill Putnam, CREG J,34, Dec 1998, p24-25.
6) An Improved Version of Ian Drummond's CB to 185kHz Transverters Brian Pease, W1IR https://radiolocation.weebly.com/uploads/2/7/5/2/27523347/improvedcb_transverter.pdf